

**State of California  
AIR RESOURCES BOARD**

**Quarterly Report to the California Legislature  
on the  
Air Resources Board's  
Fine Particulate Matter Program**

**Third Quarter 1999**

California Environmental Protection Agency

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**Air Resources Board**

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## Executive Summary

This is the first in a series of quarterly reports to the Legislature on the Air Resources Board's (ARB) fine particulate (PM2.5) program required in fiscal year 1999-2000 budget language. This report provides background on ARB's particulate programs, and covers ARB's recent accomplishments and planned activities in a number of program areas including health and exposure research, air quality monitoring, emission inventories, air quality models, planning, and control strategy development. This report on ARB's PM2.5 technical work includes activities funded through specific legislative appropriations, as well as programs funded through ARB's budget.

In general, we provide a retrospective look at the last quarter (July through September) and a look forward at the upcoming quarter (October through December). In each quarterly report, we will also highlight selected programs, providing additional background to put expected future activities in context. In this report, we highlight health and exposure research. Some highlights from the third quarter include:

- On June 30, we released our 1999 California PM2.5 Monitoring Network Description. This is the second annual monitoring plan documenting the statewide PM2.5 network design and implementation. The plan describes the new monitors we will add to the network in 1999 and 2000 to augment our existing network. We plan to add four new community-oriented PM2.5 monitoring sites (bringing the statewide total to 82). California's particulate monitoring network will also include:
  - About 30 continuous monitors to provide real-time data about particle levels in populated areas, background levels of pollution entering California from the west; and transport of pollution. Some of these monitors will be used to support monitoring efforts along the California-Mexico border and in areas with a significant amount of agricultural burning.
  - Seven speciation monitors in California's most populated areas to provide information about the chemical constituents of PM2.5.
  - Nine new visibility monitoring sites (operated by federal land managers) in or near national parks to support our regional haze program to improve visibility in scenic areas.
- In July, we received the final report of our Instrument Intercomparison Study, which evaluated emerging technologies suitable for continuous, PM2.5 mass and PM2.5 constituent measurements. New technologies based on a variety of physical principles (such as light scatter/absorption, pressure differential, energy attenuation, oscillating frequencies, flash volatilization, particle acceleration, and mass spectrometry) were evaluated against more conventional methods such as

gravimetric/filter and impactor methods. In all, about 30 types of samplers from a wide variety of manufacturers were evaluated. We identified several very promising technologies that performed well in the field. Some of these are commercially available; others are prototypes. ARB and California districts are using this report to guide purchasing decisions. In particular, it is helping us decide which continuous PM2.5 monitors to purchase this year. The report is also drawing considerable interest nationwide.

- In July, we held a symposium to begin the process of identifying data gaps and research needs related to air pollution health impacts. Approximately 40 people attended. One unique feature of the meeting was the participation of a diverse cross section of researchers and scientists to discuss our current understanding of air pollution health impacts. Discussion items included: susceptibility to air pollution impacts; air pollution and asthma; California's air quality profiles and trends; contribution of motor vehicle emissions to fine particles and hazardous air pollutants; the use of particulate measurement networks in evaluating health impacts; diesel exhaust impacts; and exposure assessment for acute and chronic effects studies. The next step will be to reconvene this group of experts and identify specific projects that can address current data gaps.
- In August, we held a workshop to discuss our current and planned emission inventory development efforts and get feedback from interested stakeholders. The workshop was well attended, with about 40 participants representing industry, environmental consultants, air districts, and academics. We will consider this input as we develop research projects for fiscal year 1999-2000.

In December 1999, we will begin a 14-month intensive field study of particulate matter in central California. The California Regional PM10/PM2.5 Air Quality Study will significantly enhance our fundamental understanding of particulate emissions, formation, and transport. The information learned will have national significance and transferability to other regions in California. California's Central Valley has one of the most serious and complex particle pollution problems in the country, making it an excellent area for such a study. The Study results will form the basis for future particulate plans and control measures. The \$27 million Study leverages state, local, and federal monies to fund this expansive effort. We will provide updates on significant Study activities in future quarterly reports.

## Introduction

Particulate matter pollution is one of the most formidable air quality and public health issues facing California. Exposure to particle pollution is linked to increased frequency and severity of asthma attacks and bronchitis, and even premature death in people with existing cardiac or respiratory disease. When particle levels in the air increase, so do reports of adverse health outcomes. Those most sensitive to particle pollution include people with existing respiratory and cardiac problems, children, and the elderly. Prolonged and repeated exposure can also have adverse impacts. Life expectancy is somewhat lower in areas with high particle levels. All inhalable particles are harmful – both “coarse” particles in the 2.5 to 10 micron diameter size and “fine” particles, those smaller than 2.5 microns.

Virtually all of California violates the state air quality standards for inhalable particulate matter less than ten microns (PM10), which includes the subset of fine particles. Several areas, both urban and rural, also violate the federal PM10 air quality standards. The U.S. Environmental Protection Agency (U.S. EPA) recently promulgated new federal air quality standards for fine particulate matter less than 2.5 microns in diameter (PM2.5) to complement their existing PM10 standards. The new PM2.5 standards have focused attention on understanding the nature of particle pollution and finding ways to reduce it.

Under the federal Clean Air Act, states must develop plans, known as State Implementation Plans (SIP), describing how and when they will attain national ambient air quality standards. With ARB technical support, the districts prepared the required PM10 SIPs. We expect PM2.5 SIPs to be due in the 2006 to 2007 timeframe. While state law does not require local districts to prepare plans for attaining the state PM10 standards, our statewide program to reduce ozone also reduces particulate levels.

It should be noted that the PM2.5 standards have been challenged in court, which is not uncommon when new standards are promulgated. In this case, the American Trucking Association and a number of other business and industry groups sued U.S. EPA to overturn the new particulate matter and 8-hour ozone standards. In June, a three judge panel of U.S. Court of Appeals returned the standards to U.S. EPA to provide a better rationale for how it selected the particular levels of the standards. U.S. EPA is appealing the decision. Although the PM2.5 and 8-hour ozone standards remain in place, the court has prohibited U.S. EPA from implementing the standards. We expect that both the PM2.5 and ozone standards will ultimately be implemented, either because they are upheld on appeal or U.S. EPA provides the clarification requested by the court.

Unlike ozone, which is a single chemical compound, particulate matter is a complex mixture of many different species generated from a wide array of sources. Particulate matter can be either directly emitted into the air in forms such as dust and soot, or it can be formed in the atmosphere (like ozone) from the reaction of gaseous

precursors such as nitrogen oxides (NO<sub>x</sub>), volatile organic compounds (VOCs), sulfur oxides (SO<sub>x</sub>), and ammonia. NO<sub>x</sub> and VOCs are also precursors of ozone pollution. Directly emitted particles are called “primary particles,” while those formed in the atmosphere are referred to as “secondary particles.” During some episodes of elevated particle levels in California, ammonium nitrate – formed secondarily from NO<sub>x</sub> and ammonia emissions – can account for over half of the PM<sub>2.5</sub> mass. Understanding how particulate ammonium nitrate is formed and how to most effectively reduce it through controls on NO<sub>x</sub> and/or ammonia sources will be a critical part of California’s PM<sub>2.5</sub> program.

Sources of ambient (outdoor) particulate matter include: combustion sources such as trucks and passenger cars, off-road equipment, industrial processes, residential wood combustion, forest/agricultural burning; fugitive dust from roads, construction, mining, and agricultural activities; and ammonia sources such as livestock operations. In general, combustion processes form fine particles, whereas particles such as dust tend to fall in the coarse range. Diesel vehicles are a significant source of particle pollution from the motor vehicle fleet. Based on our latest estimates, only two percent of California’s motor vehicles are diesel powered, but they produce about 25 percent of the NO<sub>x</sub> emissions and 60 percent of the particulate emissions attributed to motor vehicles. Because ozone and particulate matter pollution are caused by many of the same sources and precursors, many of the control strategies in California’s State Implementation Plan (SIP) for Ozone – particularly NO<sub>x</sub> controls – provide dual benefits for public health by reducing particulate matter as well.

Historically, there has been an emphasis on studying and improving the technical understanding of ozone. Consequently, the state of knowledge and the technical tools for particulate matter are not as advanced. However, in the last decade, ARB has enhanced its technical and research program for particulate matter, building the scientific foundation for the PM<sub>10</sub> SIPs adopted in the mid-1990s. This work also lays the groundwork for future SIPs to address the new federal PM<sub>2.5</sub> standards and strategies to meet the state standards. ARB is undertaking significant work to improve our understanding of particulate pollution, including: health and exposure research; expanded air quality monitoring; emission inventory improvement; development of improved air quality models; and comprehensive field studies to support the modeling efforts.

Each of these technical areas plays an important role in developing California’s PM<sub>2.5</sub> SIP which will contain the control strategy for achieving the PM<sub>2.5</sub> standards:

- *Health and exposure research* helps us understand both the impact of exposure to air pollutants (including who is susceptible to injury and the mechanisms of injury) as well as who is exposed, how much they are exposed to for how long, when and where.
- *Air quality monitoring* provides information on which areas violate the standards and how severe the problem is.

- *Emission inventories* provide an accounting of the sources of particulate matter emissions and the quantities of emissions produced from these sources.
- *Air quality models and data analysis* link air quality monitoring and inventory data with information on meteorology and atmospheric chemistry to tell us the relationship between emissions and air quality. Once we know this relationship, we can determine how much we need to reduce emissions to meet the air quality standards. We also use modeling to understand how air pollution is transported between regions. In support of our modeling efforts, we undertake extensive field studies to obtain the intensive meteorological, emissions and air quality data needed to run the models.
- *Clean air plans* describe how and when we will attain air quality standards. These plans include the technical foundation of monitoring data, emission inventories, and air quality models, as well as a control strategy for reducing emissions.
- *Control strategy development and implementation* is the critical step. Many ARB regulations provide multiple benefits – because they reduce emissions of both ozone and PM2.5 precursors, these controls provide dual benefits for public health. In this step we consider technical feasibility and cost-effectiveness as well as the socioeconomic and environmental impacts.

This report covers ARB's recent accomplishments and planned activities in each of these program areas. In general, we will provide a retrospective look at the last quarter (July through September) and a look forward at the upcoming quarter (October through December).

#### Links to Other Programs

Our program to characterize and control PM2.5 is closely related to two other ARB programs. In 1998, ARB identified particulate emissions from diesel-fueled engines as a toxic air contaminant (TAC). During the identification phase, we estimated the statewide average potential lifetime cancer risk from breathing particulate matter from diesel-fueled engines to be 450 chances in a million. This represents a significant threat to public health. We are now evaluating ways to reduce the risk associated with exposure to particle emissions from diesel engines. These risk management efforts dovetail with existing efforts to control emissions to attain the particulate matter and ozone air quality standards.

In addition, U.S. EPA recently finalized its new program to reduce the regional haze that impairs visibility in many national parks and wilderness areas. Because fine particles are a main contributor to visibility impairment, our particulate matter control program will improve visibility as well. U.S. EPA intends to integrate the timelines for

PM2.5 and regional haze planning so that the necessary technical work can be coordinated.

### California Regional PM10/PM2.5 Air Quality Study

One major particulate matter study currently underway deserves special mention. The comprehensive \$27 million California Regional PM10/PM2.5 Air Quality Study will provide much of the key technical information needed to develop PM2.5 SIPs for the San Joaquin Valley and surrounding areas. This is the largest particulate matter technical study ever undertaken. The Study will enhance our fundamental understanding of mechanisms of particulate formation and transport. The objectives of the Study are to:

- Provide an improved understanding of emissions and dynamic atmospheric processes that influence particle formation and distribution.
- Develop and demonstrate methods useful in formulating candidate control strategies for attaining the PM10 and PM2.5 standards in central California.
- Provide reliable means for estimating the impacts of control strategy options developed for PM10/PM2.5 on visibility, air toxics, and acidic aerosols and on attainment strategies for other pollutants, notably ozone.

The Study is divided into three phases – planning and basic research, field programs and emission inventory development, and modeling and data analysis. The study is currently in the second phase. A major milestone will take place this December when we will begin the field program consisting of 14 months of monitoring throughout the San Joaquin Valley and surrounding regions. The study will include intensive monitoring during fall and winter conditions when particle concentrations are highest. We will provide updates on significant Study activities in our reports for the technical program areas.

## **Health and Exposure Research**

### Health Effects Research

ARB has long recognized that particulate matter is harmful and has taken a lead in research to more clearly define how particle pollution impacts the health of Californians. Extensive research programs are underway both nationally and within California to clarify some of the uncertainties regarding who is at risk, whether a truly safe level of particulate matter can be determined, the mechanism of injury and the role of specific components of PM in producing harmful health impacts. In this first report, we highlight the ongoing PM health studies we are funding. In future reports, we will provide updates on these studies as they reach significant milestones.



- **Children's Health Study:** This major epidemiological study follows the lung development and respiratory health of approximately 5,000 school children from 12 southern California communities in 4<sup>th</sup> through 12<sup>th</sup> grades. The preliminary results of this ten-year study show that children who live in areas of high particulate matter and nitrogen dioxide show lower rates of lung growth. Children with asthma are impacted more than children that do not have asthma. In contrast, the impacts of ozone seem to relate to respiratory illness and school absenteeism. This study will proceed for four more years.
- **Cardiovascular Health Study:** This study evaluates how air pollution, including particulate matter, impacts the well-being of a group of elderly people, especially as related to their cardiac health status.
- **Health Impacts of Smoke:** This study evaluates the respiratory health impacts experienced when people breathe smoke from burning such common materials as rice straw, wood wastes, and wood used to heat homes. A combustion chamber for the study has been designed to deliver smoke levels appropriate for human exposure studies. It is being installed and tested, and the exposure studies will begin shortly.
- **Toxicological Studies of Particles:** Studies are underway in which rats are exposed to synthetic components of ambient particulate matter. These studies are evaluating cellular and tissue responses to these components, and how factors such as animal age and particle size affect observations. We hope this research will provide information on the physiological mechanisms that produce the adverse impacts observed in epidemiological studies.
- **Kaiser Hospital Study:** A study of how air pollutants impact the rates of hospitalization in the Kaiser Hospitals located in the San Joaquin Valley has been underway for the past two years. This study should help clarify the role that particulate matter plays in cardiovascular and respiratory illness in the region.
- **Vulnerable Populations Research Program:** We are currently planning several studies as part of our new vulnerable populations health research initiative. The focus of this program is to determine how air pollution, including particulate matter, impacts health and how environmental and individual health, lifestyle, and socioeconomic factors effect sensitivity to air pollution. The initial research efforts include a study of how children with asthma respond to air pollution. The study will be performed in Fresno, which has a persistent and complex particulate air pollution problem and a high rate of asthma. This study is being coordinated with major particulate air pollution monitoring efforts in the Fresno area (see Air Quality Monitoring Section). We are presently developing a request for proposals to conduct this work. We expect to issue a contract in spring 2000 with field work starting in the summer. The study will last four years.

- **Health Research Symposium:** In July, we held a symposium to begin the process of identifying data gaps and research needs related to air pollution health impacts. Approximately 40 people attended. One unique feature of the meeting was the participation of a diverse cross section of researchers and scientists to discuss our current understanding of air pollution health impacts. Discussion items included: susceptibility to air pollution impacts; air pollution and asthma; California's air quality profiles and trends; contribution of motor vehicle emissions to fine particles and hazardous air pollutants; the use of particulate measurement networks in evaluating health impacts; diesel exhaust impacts; and exposure assessment for acute and chronic effects studies. The next step will be to reconvene this group of experts and identify specific projects that can address current data gaps.

### Exposure Research

ARB is also a leader in research on exposure to particles, their toxic components and their co-pollutants. We have funded pioneering studies on Californians' exposure to particles in indoor, outdoor, and in-vehicle micro-environments, and on actual "personal exposure" – the air pollutant levels in our breathing areas. We sponsor research to fill data gaps and develop key monitoring and analytical methods needed for accurate exposure assessment. We also publish practical guidelines on how to reduce personal exposures to indoor and outdoor pollutants, including particles. In this first report, we provide a brief background of previous work and a summary of on going studies. In future reports, we will provide updates on significant study milestones.

We have previously sponsored or co-sponsored two ground-breaking studies of Californians' PM<sub>2.5</sub> exposures. The **Particle Total Exposure Assessment Methodology Study**, the first major field study of population exposure to PM<sub>2.5</sub> and PM<sub>10</sub>, measured indoor and outdoor PM<sub>2.5</sub> levels at 178 homes in Riverside in 1990. The study revealed that: indoor PM<sub>2.5</sub> levels were sometimes greater than outdoor levels and were highly variable among homes; about 75 percent of the indoor PM<sub>2.5</sub> came from outdoor sources; and that nearly all of the outdoor PM<sub>2.5</sub> reached the indoor environment. Smoking and cooking were identified as major indoor sources of particulate.

The recently completed **In-Vehicle Pollutant Measurement Study** was the first large-scale study to measure PM<sub>2.5</sub> and PM<sub>10</sub> inside motor vehicles as they were driven on California roadways. The results showed that in-vehicle PM levels were usually higher than levels measured along the roadside or at ambient monitoring stations. In-vehicle levels of fine particles were especially high when following a diesel vehicle or a gross-emitting gasoline vehicle, and the increase occurred very rapidly. We plan to build on this study by measuring PM levels and related exposure factors in school buses and other vehicles.

ARB is currently funding three major studies on PM<sub>2.5</sub> exposures:

- **Residential Indoor Cooking Exposures Study:** This is the first comprehensive study of indoor emissions and levels of PM2.5, PM10, and particles down to 0.02 microns during residential cooking. Pollutants will be measured in test houses during eight different cooking activities under various conditions using both gas and electric stoves, different cooking utensils, and different exposure reduction methods. We will use the data from this study to improve exposure estimates and to further explore the correlation between elevated personal exposure levels and cooking activities seen in previous studies. The data will also be used to provide guidance to the public on reducing their pollutant exposure. In the upcoming quarter, preliminary test data will be analyzed and the main testing will begin. The study will be completed late in 2000.
- **Sources of Personal, Indoor, and Outdoor PM Exposures of Chronic Obstructive Pulmonary Disease Patients:** This is the first extensive study of personal exposure to PM2.5 in California. The main objective is to quantify the contribution of outdoor air to indoor and personal PM2.5 exposure levels. Investigators will study 15 patients with chronic obstructive pulmonary disease, a sensitive group with severe lung disease. Investigators will measure personal exposures and residential indoor and outdoor levels of PM2.5, PM10, and gaseous co-pollutants in the Los Angeles area. They will also measure the chemical components of PM2.5 and use these data to help identify significant indoor and outdoor pollutant sources that could not be identified in previous studies. In the upcoming quarter, we will continue planning and field preparation for the study which will run through 2001. Results of this study will enable us to better understand the link between outdoor PM2.5 and the health effects seen in sensitive individuals. U.S. EPA is funding companion studies in Boston and Atlanta.
- **Indoor Exposure Model Enhancement:** This project will enhance the capabilities and accessibility of a model to estimate total exposure to particles and other air pollutants from all microenvironments – indoor and outdoor. The model is based on California data for pollutant concentrations, building ventilation, and human activity patterns. We will use the model to more accurately estimate Californians' exposures to particles, including toxic components such as diesel particles and metals. We can also use it to evaluate the effectiveness of different risk reduction strategies. The project will be completed in 2001.

## Air Quality Monitoring

ARB's air quality monitoring program provides information used to determine which areas violate standards, characterize the sources that contribute to pollution, assess pollution transport, and support health studies and other research. Monitoring data also provide the ultimate check on how effective our programs are – is the air quality improving? California already has a mature PM10 air monitoring network, with over 150 monitors located throughout the state. In order to assess the nature and

extent of the PM2.5 problem in California, ARB and local air districts are enhancing and expanding the PM2.5 monitoring program. ARB is augmenting our existing PM2.5 monitors with federally approved PM2.5 monitors and samplers to measure particle constituents. This effort began in 1998 and will continue for several years until our network is fully deployed.

Monitoring of the individual species that make up particulate matter is still an emerging field, with continuous speciation measurements the greatest challenge. To develop the best speciation network, California will need to take full advantage of emerging technologies – including instrumentation that is not yet commercially available. We are participating in the development of new sampling technology and critical research in this field, including special studies to evaluate newly emerging methods not currently used in routine monitoring. With previously allocated funds, we will purchase and deploy the first round of equipment by early 2000, and phase in purchase of the remaining monitors through 2001 to allow additional time to assess which technologies are the most effective.

As part of California's monitoring program, we have developed a comprehensive quality assurance program for the PM2.5 monitoring data. This program includes routine system and performance audits for both field and laboratory operations. System audits provide qualitative information about the monitoring program as a whole, while regular performance audits provide quantitative results on the performance of sampling equipment and laboratory facilities.

In May, ARB's air monitoring station in Fresno became the first air quality monitoring "Super Site" in the country. This is the first of seven planned "Super Sites" to be established in urban areas by U.S. EPA to conduct intensive and advanced measurements for particulate matter. The collaborative program operates research-grade air monitoring stations to advance PM2.5 measurement technologies, accelerate the replacement of current technologies with advanced sampling methods, provide advanced measurements that support PM2.5 and ozone programs, provide information for health risk assessments related to fine particulate matter and its components, and establish collaborative partnerships between the research and regulatory monitoring communities. Monitoring will continue for one year.

### **Current and Future Quarterly Activities**

- **1999 PM2.5 Monitoring Plan.** On June 30, we released our *1999 California PM2.5 Monitoring Network Description*. This is the second annual monitoring plan documenting the PM2.5 network design and implementation. We worked closely with local air districts, U.S. EPA, and the public in developing this plan. In 1998 (the first year of phase-in of the new PM2.5 monitoring network), we established 78 sites to monitor PM2.5 mass. The plan describes the new monitors that ARB and districts will add to the network in 1999 and 2000, including:

- *Mass samplers.* We intend to add four additional monitoring sites to round out our network of PM2.5 mass samplers. These samples collect data for comparison to the federal PM2.5 air quality standards.
- *Continuous mass samplers.* We intend to add 25 monitoring sites to provide “real time” continuous mass data which will be used to inform the public about particulate matter levels in their communities, as well as provide information on how particle concentrations vary hour by hour. Some of these monitors will be used to support monitoring efforts along the California-Mexico border and in areas with a significant amount of agricultural burning. We also plan to deploy continuous samplers at three sites to measure background levels of the air entering the state from the west.
- *Transport assessment.* We intend to establish two sites to assess transport of particle pollution in coordination with the California Regional PM10/PM2.5 Air Quality Study. These sites will include continuous PM2.5 mass samplers and meteorological monitoring equipment.
- *Speciation samplers.* Speciation samplers provide valuable information about the composition (and ultimately sources) of PM2.5 pollution. Because the technology to effectively monitor these individual species is still emerging, we will take an incremental approach in deploying our speciation network. We plan to phase in the speciation network over the next three years to allow time to better evaluate unproven sampling technologies. In early 2000, we intend to deploy seven speciation sites required by U.S. EPA regulations to measure long-term trends of selected PM2.5 constituents. We are planning to deploy the remainder of our speciation network in 2000 and 2001.
- *Visibility monitoring.* U.S. EPA is expanding the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, consisting of sites in national parks and wilderness areas, as part of the federal regional haze program. Data from the IMPROVE network will provide useful speciation and background concentration information to augment our PM2.5 monitoring program. We have been involved in the site selection process to bring the network closer to meeting California’s needs for both the regional haze and PM2.5 programs. Working closely with Federal Land Managers in California, we have persuaded the IMPROVE Steering Committee to increase the number of IMPROVE sites in California from 8 to 17.
- **Speciation monitor evaluation.** In July, we received the final report of our Instrument Intercomparison Study which evaluated emerging technologies suitable for continuous, PM2.5 mass and PM2.5 constituent measurements. The University of California, Davis (UCD) conducted the evaluation of more than two

dozen technologies on our behalf. The field study took place at the ARB's monitoring station in Bakersfield this past December and January. New technologies based on a variety of physical principles (such as light scatter/absorption, pressure differential, energy attenuation, oscillating frequencies, flash volatilization, particle acceleration, and mass spectrometry) were evaluated against more conventional methods such as gravimetric/filter and impactor methods. In all, about 30 types of samplers from a wide variety of manufacturers were evaluated. We identified several very promising technologies that performed well in the field. Some of these are commercially available; others are prototypes. ARB and California districts are using this report to guide purchasing decisions. In particular, it is helping us decide which continuous PM<sub>2.5</sub> monitors to purchase this year. The report is also drawing considerable interest nationwide

### California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study

- Activities during the third quarter have focused on refining the suite of measurements and sites for the annual field monitoring program. Sites have been located for the air quality and meteorological monitoring, and final instrument selections have been made. Contracting was initiated for site operations, chemical analysis, quality assurance, and construction of a 100 meter air quality and meteorological monitoring tower.
- Work during the fourth quarter will focus on the installation and calibration of the monitoring equipment needed at each site. The field study will begin on December 1, 1999 and continue through January 31, 2001.

### **Emission Inventory Development**

Over the last year, ARB has embarked on a program to identify and characterize the sources of emissions of PM<sub>2.5</sub> and its precursors. This work will lead to the development of a statewide inventory of the emissions and sources of PM<sub>2.5</sub>. The emission inventory will include estimates of future emissions, which consider growth and the benefits of adopted air quality programs. By accurately quantifying PM<sub>2.5</sub> emission sources, we can better target our control strategies.

ARB's existing emission inventory includes particulate emissions estimates for directly emitted total suspended particulate and PM<sub>10</sub>. Our inventory also includes estimates for gaseous precursors, such as NO<sub>x</sub>, SO<sub>x</sub>, and VOCs. We are now incorporating emission estimates for PM<sub>2.5</sub> particles, as well as additional particulate precursors such as ammonia. Because PM<sub>2.5</sub> emissions are difficult to measure and characterize, this will be a multi-year effort. By 2001, we intend to produce draft emission inventories for PM<sub>2.5</sub> and ammonia, which can be used for identifying the most important sources of PM<sub>2.5</sub> air pollution. These inventories are being developed in coordination with the air districts, U.S. EPA, industry, and researchers.

ARB funds a number of projects to quantify and better understand PM<sub>2.5</sub> emissions from stationary, area, and mobile sources. In this first report, we describe some of these projects. In future reports, we will provide updates of significant research milestones.

- **Ammonia Emissions From Fertilizer Application and Soils:** Working closely with the agricultural community, this project will apply various ammonia-based fertilizers to different soil and crop types in the San Joaquin Valley. The ammonia emissions that result from the fertilizer application will be quantified, and the data used to generate regional and seasonal estimates of fertilizer related ammonia emissions.
- **Commercial Charbroiling and Deep-Fat Frying Operations:** The results of this project will allow the ARB to estimate regional and statewide particulate emissions resulting from commercial charbroiling and deep-fat frying based on the number and location of these sources, and estimates of the quantities of food cooked.
- **Dust Emissions From Vehicle Travel Over Paved Roads:** This project will use a vehicle instrumented with real-time particulate measuring devices to develop more accurate estimates of dust from vehicular travel on paved roads. This information will help provide an understanding of what activities lead to high road dust emission rates and what can be done to reduce them.
- **Emissions From Wildland Fires:** This project will provide a consistent, statewide method for estimating smoke emissions from wildland fires, incorporating satellite data, geographic vegetation data, fire modeling, and other available information. The work is being closely coordinated with staff from the California Department of Forestry and the U.S. Forest Service to take full advantage of the wildland burning expertise these agencies possess.
- **Ammonia Measurement Instrumentation:** This project will develop instrumentation which will allow characterization of ammonia plumes in near real-time. The results of the project will ultimately help to evaluate ammonia emission levels from sources that are difficult to measure using standard techniques and determine how to best reduce ammonia levels if needed.
- **Off-Road Diesel Equipment Emissions:** This project will develop test cycles for heavy-duty, off-road equipment based on real world activity and use. The project will also test the engines for ROG, NO<sub>x</sub> and particulate matter pollutants.
- **Other Off-Road Equipment Emissions:** This project will develop and implement a methodology to measure particulate matter emissions, including PM<sub>2.5</sub>, from marine outboard engines, personal watercraft and small off-road equipment such as lawnmowers.
- **Two-Stroke Utility Engines:** This project will assess the durability of low-emitting two-stroke engines (such as those used in lawn and garden equipment) by

measuring ROG, NOx and particulate matter pollutant emissions, including particulate matter, in both new and used engines.

In addition, ARB is in the process of obtaining the chassis dynamometer testing facility originally managed by the Los Angeles Metropolitan Transit Authority. This facility will be used to perform both engine- and chassis-based emissions tests (including PM2.5) of heavy-duty vehicles on a regular basis. (Chassis dynamometers are treadmill-like devices that test engine-vehicle combinations. Engine dynamometers test engines that have been removed from, or are not yet installed in, vehicles.) Data will be used to update the emission inventory.

### **Current and Future Quarterly Activities**

- **Emission Inventory Research Workshop.** To assist us in prioritizing future PM2.5 research, we held a workshop in August to discuss our current and planned emission inventory development efforts and to get feedback from interested stakeholders. The workshop was well attended, with about 40 participants representing industry, environmental consultants, air districts, and academics. The comments we received were very useful in helping to target our resources. (The specific comments and additional information are available on our website at: [www.arb.ca.gov/emisinv/pmnh3/pmnh3.htm](http://www.arb.ca.gov/emisinv/pmnh3/pmnh3.htm).) In the fourth quarter, we will develop research projects for FY 1999-2000 considering the input from the workshop.
- **Ammonia Inventory.** In the fourth quarter, we will continue our efforts to develop an ammonia inventory. We plan to meet with beef and dairy cattle industry representatives to get their input and assistance in estimating emissions from livestock.

### **California Regional PM10/PM2.5 Air Quality Study**

- As part of the Study, a comprehensive particulate matter and precursor species emission inventory will be developed to support modeling and data analysis of the information collected during the field programs, including data on motor vehicle activity and activity data for other PM generating sources. During the fourth quarter of this year, we will also release requests for proposals for several ammonia emissions projects which will focus on non-agricultural and urban sources of ammonia.

### **Air Quality Modeling**

ARB develops air quality models and runs these models to predict how emissions, weather, and terrain influence ambient levels of pollutants, based on monitoring data, emission inventories, and atmospheric chemistry. Air quality models are also used to determine the emission reductions needed to achieve air quality standards and to evaluate the effectiveness of control strategies. Regional models are



used to assess pollution transport from one area to another. These types of transport assessments are needed to ensure that all actions necessary to meet air quality standards are taken in both upwind and downwind districts.

California has developed some of the most advanced photochemical models in the nation for ozone. However, the state of modeling is not as advanced for particulate matter, in part because of a lack of the extensive air quality and meteorological data needed to run modeling simulations. A major challenge for ARB will be advancing the state of particulate matter modeling for use in developing PM<sub>2.5</sub> attainment plans and control strategies. For attainment planning, the PM<sub>2.5</sub> modeling analyses must show the “carrying capacity,” or how many tons of emissions each affected area can hold before it exceeds the daily or annual PM<sub>2.5</sub> standards. The carrying capacity for PM<sub>2.5</sub> and precursors determines the type and amount of emission reductions needed from new control measures. PM<sub>2.5</sub> models will also form the basis for regional haze models to assess the impact of our control strategies on visibility in California and in downwind states.

## **Planning**

The timeline for developing PM<sub>2.5</sub> attainment plans (SIPs) is dictated by when nonattainment areas are designated, which in turn is dictated by when PM<sub>2.5</sub> air quality monitoring data are available. Although California had a small pre-existing PM<sub>2.5</sub> monitoring network, no nationwide PM<sub>2.5</sub> monitoring network or federally approved monitor for measuring PM<sub>2.5</sub> levels existed when the new federal standards were promulgated in 1997. We began collecting PM<sub>2.5</sub> monitoring data for comparison to the standards in 1999 at many sites in California. Three years of monitoring data are needed to designate areas as attainment or nonattainment. In addition, when U.S. EPA promulgated the PM<sub>2.5</sub> standards, it agreed to complete its next health review of the standards prior to designating areas. That review is scheduled to be finished in 2002. Thus, we expect nonattainment areas will be designated in 2003, at the earliest. SIPs would then be due three years later – or 2006 at the earliest.

This schedule is still tentative – in part, due to an ongoing legal challenge to the new standards. The exact implementation schedule will not be set until the court case is settled. Because the planning timelines are relatively long and deployment of the monitoring network is not being delayed, it is likely that the legal challenge will be resolved without ultimately delaying the schedule for submitting PM<sub>2.5</sub> SIPs. U.S. EPA will issue guidance detailing the specific planning requirements and timelines for the PM<sub>2.5</sub> standards. However, guidance development is on hold pending resolution of the court case.

For regional haze, U.S. EPA intends to require visibility SIPs in the same year as PM<sub>2.5</sub> SIPs. The new regional haze regulation also provides an option for the nine states which participated in the Grand Canyon Visibility Transport Commission (including California). These states may choose to pursue an accelerated plan submittal in 2003, based on the Commission’s recommendations for improving visibility

at the Grand Canyon. We will coordinate with other western states as we develop a regional haze SIP in 2003 to address our contribution to visibility impairment in the Grand Canyon region. We will address visibility concerns for national parks and wilderness areas in California in coordination with our PM2.5 SIP in the 2006 to 2007 timeframe.

## **Control Strategy Development and Implementation**

ARB develops control strategies for stationary, area, and mobile sources to reduce emissions and achieve air quality goals. The development of control strategies is based on emission inventories and modeling data, the need for additional reductions to meet state and federal requirements, existing controls, and technical feasibility. Control strategies are also evaluated for cost-effectiveness, and socioeconomic and environmental impacts. Our assessment of the controls needed to attain state and federal standards will include estimating the PM2.5 benefits from current and planned control programs for PM10 and ozone.

In addition to regulations, we are also pursuing emission reductions from voluntary programs, such as the Carl Moyer Program. The Program provides grants for the incremental cost of cleaner, heavy-duty trucks, buses, boats, agricultural equipment, and other categories. The Moyer Program focuses on NOx reductions, which provide dual benefits for ozone and PM2.5. Depending upon the technology used, some projects also provide reductions in direct particulate matter emissions. For example, projects that replace diesel engines with natural gas engines reduce NOx and eliminate diesel particulate emissions. Demand for project funding has been three times the available funding.

This spring, we started planning for future mobile source control measures. We are reviewing all mobile source categories to determine the potential for additional emission reductions. Potential measures will be identified for inclusion in the next revision to California's Ozone SIP. Although the focus of our next comprehensive clean air plan will be ozone, as we develop future mobile source measures, we will consider their impact in reducing particle as well as ozone pollution. We plan to present a comprehensive revision to our air quality plan to the Air Resources Board in the 2000 to 2001 timeframe.

## **Current and Future Quarterly Activities**

- **Transit Bus Standards.** We are currently developing lower emission standards for urban transit buses, including long-term standards that would require the use of zero-emitting technology, such as fuel cells, by 2010. This rule is expected to have both immediate and long-term NOx and particulate emissions benefits. We have scheduled a workshop for October and expect to bring this proposal to the Board in early 2000.

- **Heavy-Duty Diesel Off-Road Equipment Standards.** We are developing lower emission standards for heavy-duty diesel, off-road equipment. These standards will be based on a 1996 agreement between ARB, U.S. EPA, and the engine manufacturers and will phase-in beginning in 2001 – four years earlier than anticipated in the 1994 Ozone SIP. These regulations will reduce emissions of NO<sub>x</sub>, a PM<sub>2.5</sub> precursor, as well as direct particulate emissions. We expect to bring this proposal to the Board in December. In addition, more stringent particulate matter standards for diesel, off-road equipment will be considered in a technical review to take place in 2001.
- **Proposed Determination of RACT/BARCT for Stationary IC Engines:** We are currently working with the California Air Pollution Control Officers Association (CAPCOA) to develop a proposed determination of reasonably available control technology and best available retrofit control technology (RACT/BARCT Determination) to reduce emissions from stationary internal combustion (IC) engines. The California Clean Air Act requires areas that do not attain the state ozone standard to apply either RACT or BARCT to stationary sources, depending upon the severity of the local air quality problem and magnitude of emissions from a facility. The RACT/BARCT determination would assist districts in establishing emission control measures for IC engines, and would promote consistency of controls for similar emissions sources among districts with similar air quality. In August, we sent our latest proposal to a district workgroup. After considering the district's input, we will schedule public workshops to discuss our proposed determination, followed by Board consideration at an upcoming Board meeting. Because these emission limits will reduce fine particulate precursors, such as NO<sub>x</sub>, they will also reduce particulate pollution.

For this first report, we also provide background information on two major control efforts, smoke inspection programs for diesel trucks and risk management from exposure to emissions from diesel engines. In future reports, we will continue to provide status reports and updates on these programs.

### Smoke Inspection Programs for Heavy-Duty Diesel Vehicles

ARB, in cooperation with the California Highway Patrol (CHP), administers two smoke inspection programs: the roadside Heavy-Duty Vehicle Inspection Program (HDVIP) and its companion, the Periodic Smoke Inspection Program (PSIP) for fleets. Under these programs, all heavy-duty trucks and buses traveling in California, including those registered in other states and foreign countries, are subject to inspection and testing. Smoke opacity and tampering inspections are performed at CHP weigh stations, random roadside locations, California-Mexico border crossings, and at fleet locations statewide. Pre-1991 engines fail if the smoke opacity (density) is 55 percent or greater, while 1991 or newer engines fail with an opacity of 40 percent or above.

For both the roadside HDVIP and fleet PSIP, smoke opacity checks are performed in accordance with Society of Automotive Engineers (SAE) test protocols using an opacimeter. Owners of a failing truck or bus are issued citations that assess

graduated civil penalties up to \$1800. Cited vehicle owners must also submit proof of repair demonstrating compliance within 45 days from the date of citation. Non-penalty "Fix-it tickets" (Notices of Violation) are issued for pre-1991 engines if the smoke opacity is between 55-69 percent. Under the fleet PSIP, all California fleets with two or more trucks or buses are required to perform annual smoke and anti-tampering inspections. Fleet owners are required to repair and retest all vehicles that fail the opacity test. To ensure compliance, ARB randomly audits fleets' inspection and maintenance records and audit tests a representative sample of their vehicles.

Currently, we have 21 field inspectors and 2 fleet auditors enforcing both of these programs statewide. We also have a number of ongoing studies to support and improve the programs. We are working with the American Trucking Association Foundation to evaluate the effectiveness of smoke-related repairs by cited vehicle owners. We will share our findings with the trucking and bus industries to help educate them on how to make cost effective repairs. In addition, we are working with SAE to establish a smoke opacimeter evaluation program to ensure that marketed opacimeters comply with SAE specifications. In October, we will present a status report on the inspection programs to our Board.

- **HDVIP Status:** As of August 1, we have inspected 25,327 vehicles since restarting the program in June 1998. These inspections have resulted in 1,689 citations and 463 Notices of Violation. The failure rate has decreased from 11 percent when the program was first restarted to 9 percent currently. More than 1,300 trucks and buses have been repaired, with more than \$359,000 being collected in civil penalties. Industry acceptance of the program seems to be good as indicated by the low rate of citation appeals (2 percent) as compared to the 15 percent appeal rate during the period we ran a similar program from 1991 through 1993.
- **PSIP Status:** In June, we issued a notice to all California fleets (over 28,000) reminding them of their obligation to perform annual smoke inspections by October 1 as required under the fleet PSIP. During this reporting period, we conducted 18 fleet audits.

### Risk Management for Diesel-Fueled Engines

Since identifying particulate emissions from diesel engines as a Toxic Air Contaminant (TAC), ARB has embarked on a major effort to characterize and manage the risk. To assist with our program, we formed an Advisory Committee of representatives from industry, environmental groups, government agencies, and the public. The Advisory Committee and its five subcommittees (Risk Management, Mobile Sources, Fuels, Stationary Sources, and Alternative Strategies) will provide us with input as we proceed with the risk management activities. Existing and planned programs to reduce particulate emissions from diesel engines will help reduce emissions and risk. If additional cost-effective measures to reduce public exposure are

identified, we will develop specific control measures. A ban on diesel fuel or all diesel-fueled engines is not being considered.

- **Needs Assessment:** ARB, in consultation with the Advisory Committee, the districts, affected industries, and the public, is developing a “needs assessment” report to: identify the current public health impact of particulate emissions from diesel-fueled engines; determine the effectiveness of programs currently in place; and determine what technically and economically feasible strategies could be pursued to further reduce emissions. We plan to release a draft needs assessment report in December and finalize the report in Spring 2000.
- **Risk Management Guidelines:** We are developing guidelines to assist the districts in permitting new and modified stationary sources that operate diesel-fueled engines. We released a work plan and draft outline for the guidelines in August. We plan to release the draft permitting guidelines in December, with the final guidelines tentatively scheduled for Spring 2000.
- **Petition to Reconsider TAC listing:** On July 1, we received a petition requesting the Board reopen the scientific review process for its listing of particulate emissions from diesel-fueled engines as a TAC, and re-examine whether the listing is warranted. The petition further requested that the Board withdraw the cancer unit risk factor for diesel particulate and suspend all risk management activities. The petition was submitted by the following organizations: the American Trucking Associations, California Chamber of Commerce, California Farm Bureau Federation, California Manufacturers Association, California Trucking Association, Engine Manufacturers Association, Truck Manufacturers Association, and the Western States Petroleum Association. We reviewed the information and concluded that it reflects additional interpretations of studies already extensively reviewed during the multi-year diesel exhaust risk assessment process. On this basis, and for other reasons identified in the decision, we denied the request to re-examine the identification of particulate emissions from diesel-fueled engines and are continuing our risk management activities.